ANALELE ŞTIINTIFICE ALE UNIVERSITĂŢII „AL. I. CUZA” IAŞI
Tom LVIII, s. II – c, Geografie 2012
ISSN 1223-5334 (printed version)

SCIENTIFIC ANNALS OF “Al. I. CUZA” UNIVERSITY OF IAŞI
Volume LVIII, s. II – c, Geography series 2012
(online version) 2284-6379 e-ISSN

GULLY EROSION WITHIN THE RACUL CATCHMENT (CENTRAL MOLDAVIAN PLATEAU, ROMANIA)

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Abstract: Gully erosion within the Racul catchment. The Racul catchment is located in the Central Moldavian Plateau, having a total area of 3,990 ha. With the help of aerial photographs and field measurements and observations, 67 gullies were identified, stretching on a 0.29 km^2 area (0.7% of the catchment’s total area). The comparative analysis of the information in the topographic maps (1977), aerophotograms (2005, 2009) and topographic levelling (2011) on a representative group of 17 gullies allowed the estimation of some gullying indices, such as gully-head advance and areal gully growth.

Keywords: *gullying, gully-head advance, aerial photos*

I. INTRODUCTION

The gullying presence, type and frequency depend on the characteristics of the triggering factors and the circumstances that lead to their appearance. Natural conditions that control the location, abundance and type of gully erosion include local and regional morphological and lithological frameworks, type and thickness of the soil cover and type and area of the vegetation cover. Usually triggered and accelerated by changes in land use or extreme climatic phenomena, the gullying processes are the result of a collection of historical factors that cannot be omitted in trying to understand the spatial erosion models (Valentin et al., 2005).

Within the Moldavian Plateau, a series of papers have been published, all of them approaching different aspects of the gullying processes, from the quantification and spatial distribution analysis of the gullies to a complex statistical-geographical analysis of their spatial-temporal evolution at regional (Ioniță, 2006; Rădoane et al., 1995) or local level (Niacșu and Ioniță, 2011).

II. THE STUDY AREA AND THE WORK METHODS

The Racul catchment, a left-side affluent of the Vasluieț, is a part of the typical hilly area of the Central Moldavian Plateau, and administratively located in the Micleşti and Soleşti communes territory, Vaslui County (Fig. 1).

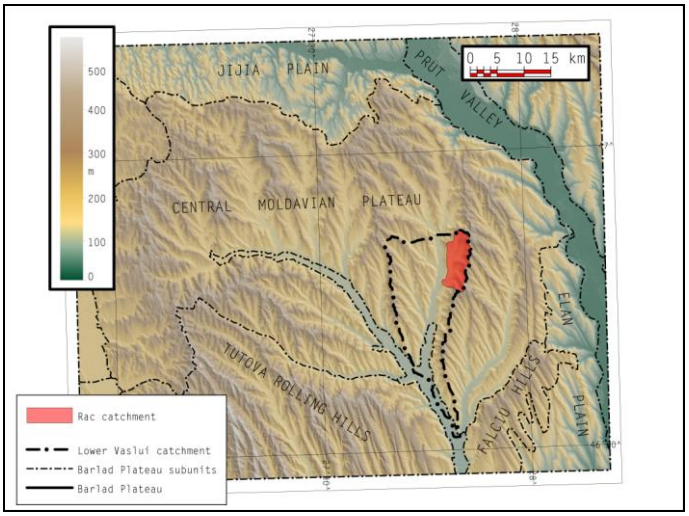

Fig. 1. Position of the studied catchment within the Moldavian Plateau

Within the 3,990 ha catchment, altitudes range between 424.6 m, value registered on the interfluvial hilltop which separates the Racul from the Crasna river, and 113 m, value registered towards the junction with the Vasluieț river. The climate is continental with excessive nuances, having average multiannual temperature values of 8.4^0 C and average multiannual precipitation of 570 mm per year. The climatic parameters for the studied area were calculated with a regression equation, which has the hypsometry, geographic coordinates, annual average temperatures and annual average precipitation as variables. The input data were obtained from the Moldavian Regional Meteorological Center in Iaşi.

Geologically, the Racul catchment is in the maximum development area of the Kersonian characterized by littoral and delta facies, with cross-structure and sandstone intercalations (Jeanrenaud and Saraiman, 1995). The middle Sarmatian (Bessarabian) formations occur in the inferior third of the slopes, and the Meotian is encountered on the higher interfluvial hilltops, as erosion remnants.

Geomorphologically, the dominant topography is sculptural, developed on a generally monoclinal structure (Băcăuanu, 1980). Interfluvial hilltops and slopes, which are predominant within the catchment, are typical to the entire region.

Within the Racul catchment, the valley's direction is initially obsequent and then subsequent, the valley having a consequent direction from the Chirceşti village onwards. Overall, the consequent aspect becomes dominant by highlighting the subsequent asymmetry (Ioniță, 2000), where the right slope is a typical cuesta backslope with eastern exposition, very well outlined and uniform, while the left slope is a cuesta front with western exposition, fragmented by a series of subsequent left affluents, east-west-oriented (e.g. Valea Popeşti, Valea Fundătura). All these subsequent segments highlight the primary structural asymmetry, where the right slope is a cuesta backslope with southern exposition, while the left slope is a cuesta front with northern exposition (Fig. 3). Due to the pronounced deepening of the hydrographic network, the majority of the southern exposition backslopes are highly steeped and degraded, encouraging the occurrence of gullying (Fig. 4).

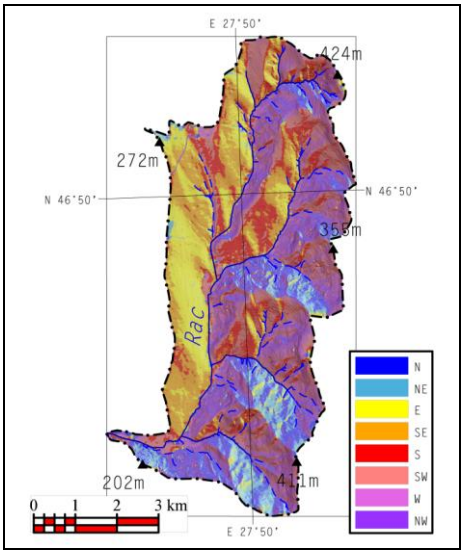

Fig. 3. Slope aspect map

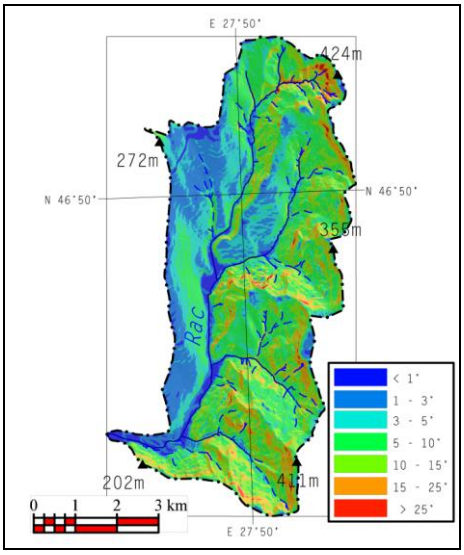

Fig. 4. Slope declivity map

The soil cover of the arable land consists of Chernozems (typic, cambic) with a low or medium carbonates content and Phaeozems (typic, cambic, calcaric) and Preluvosols (typical, mollic and even stagnic) on the higher areas. This soil cover is completed by the presence of azonal and intrazonal soils, the typical and mollic Erodosols type, and the typical and calcaric Regosols and Aluviosols type (Pedology and Agrochemistry County Offices - PACO, Vaslui, 2001, 2007).

For a more accurate characterization of the Racul catchment, a series of digital maps in raster and vectorial format were drafted through spatial analysis, being combined to highlight some particularities of the natural framework in this

region. In raster format, the main drafted maps characterize the morphometry of the region and a series of layers required in the spatial analysis. The Digital Elevation Model was achieved by processing the topographic maps on the 1:5000 scale (Fig. 5). For the Racul catchment, we used 13 topographic maps. They were scanned, imported in the GIS software used, TNT MIPS 6.9, and then georeferenced in the Stereo 1970 coordinates system (Microimages, Inc., 2008). Also, to draft some gullying evolution and distribution maps in the studied area, we used aerophotograms on the 1:5000 scale (Fig. 6) obtained from the National Agency for Cadastre and Land Registration (NACLR, 2005, 2009).

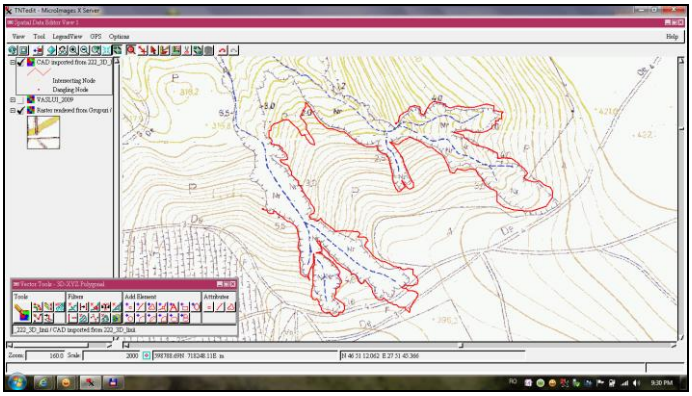

Fig. 5. Topographic levelling in 2011 overlaid on topographic map, 1:5,000 scale, 1977 edition

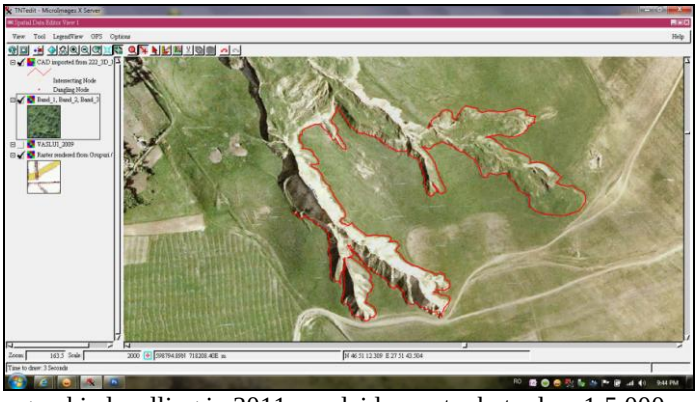

Fig. 6. Topographic levelling in 2011 overlaid on ortophotoplan, 1:5,000 scale, 0.5m x 0.5m resolution, 2005 edition

The interpreting of the stereoscopic aerophotograms was completed through field observations and examination of the bibliographic and historical data, including geological and geomorphological maps. The field mappings were made

with the Leica total station and the South S-82 GPS, and the topographic elevations and longitudinal and transverse profiles were based on them.

III. RESULTS AND DISCUSSIONS

The first results of our analysis refer to the gully distribution and density within the studied area. These aspects were obtained by inventorying the gullies existing in the topographic maps and the ortophotoplans. Thus, as it can be noticed in the gully distribution map, two distinctive gullying concentration areas can be observed. One is located in the superior catchment, upstream from the Chirceşti village, inserted in an old landslide diluvium on Chersonian deposits, and the other located in the south of the catchment, in the Popeşti and Fundătura valleys (Fig.).

This distribution is explainable through the dominant lithology and through morphology and morphometry. Within the Racul catchment, a series of 67 gullies have been inventoried, most of them having an area smaller than 1 ha. The gullied area is 0.29 km^2, representing 0.7% of the catchment's total area. The density, calculated as the number of gullies reported to the total area of the catchment, has a value of 1.7 gullies/km^2, a relatively normal value for the Central Moldavian Plateau. The main cause that leads to the formation and the development of gullies is the impact of human activities. The road network and the up-and-down hill farming have led to a concentrated slope flow. The anthropic factor action is also completed by the natural conditions, such as some morphometric elements: slope, relief energy and the soil erodability.

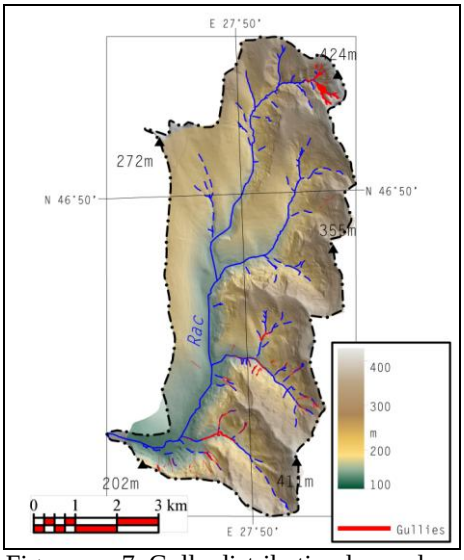

Figure no. 7. Gully distribution layered on hypsometry

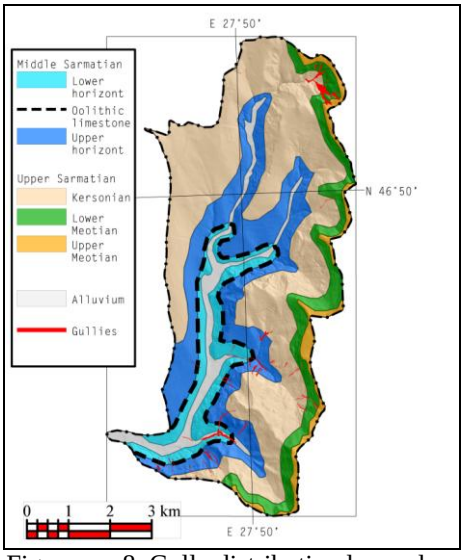

Figure no. 8. Gully distribution layered on geology

Starting from the 67 gullies inventoried in the Racul catchment, we selected a series of 17 representative gullies in the ortophotoplans. By comparing the situation found in the ortophotoplans (2005) to the one found in the topographic maps (1977), some gullying indices were calculated, indices that can define the evolution of the process in real parameters.

The first parameter is the mean length of the gully-head advance. The values calculated for the 17 gullies, in a 28-year period, show a mean gully-head advance of 0.9 m/year (Table no. 1).

Table 1. Gullying average indices measured on topographic maps (1: 5 000, 1977 edition) and ortophotoplans (1:5 000, 2005 edition)

Nr.	Gully	Levelling year	S 77-05 (sqm)	L (m)	Smed (sqm/year)	Lmed (sqm/year)	Volume (m^3/year)*	Quantity (t/year)*
1	**Racul - Fundăturii Sud**	**1977**	**599.7**	**53.4**	**21.4**	**1.9**	**354.4**	**579.4**
2	**V. Fundaturii_Vf_1**	**1977**	**665.9**	**29.4**	**23.8**	**1.1**	**215.0**	**369.2**
3	V. Fundaturii_Vf_2	1977	244.6	25.0	8.7	0.9	190.0	331.6
4	Racul - Agaricioaia	1977	143.7	11.0	5.1	0.4	110.1	211.7
5	Popeşti - Sud_1	1977	63.2	7.3	2.3	0.3	89.7	181.1
6	Popeşti - Sud_2	1977	110.7	9.0	4.0	0.3	99.0	195.1
7	Popeşti - Sud_3	1977	181.5	19.6	6.5	0.7	158.9	284.9
8	**Popeşti - obârşie**	**1977**	**520.3**	**74.1**	**18.6**	**2.6**	**477.4**	**765.8**
9	Popeşti - şcoală_1	1977	236.4	27.6	8.4	1.0	204.5	353.5
10	**Popeşti - şcoală_2**	**1977**	**355.7**	**37.2**	**12.7**	**1.3**	**259.8**	**436.7**
11	Popeşti - Humăriei_Vf_1	1977	404.2	14.8	14.4	0.5	131.8	244.3
12	Popeşti - Humăriei_Vf_2	1977	222.7	12.8	8.0	0.5	120.7	227.6
13	Velniţa Chirceşti_Vf_S_1	1977	249.6	6.6	8.9	0.2	85.3	174.6
14	**Velniţa Chirceşti_Vf_S_2**	**1977**	**903.0**	**35.5**	**32.3**	**1.3**	**249.9**	**421.8**
15	Velniţa Chirceşti_Vf_S_3	1977	290.2	14.6	10.4	0.5	130.7	242.6
16	**Velniţa Chirceşti_Vf_N**	**1977**	**374.6**	**36.6**	**13.4**	**1.3**	**256.4**	**431.6**
17	Velniţa Chirceşti_Vf_E	1977	95.3	9.9	3.4	0.4	103.8	202.3
	Mean		**333.0**	**25.0**	**11.9**	**0.9**	**190.4**	**332.6**

Above-average values have been registered in the Popeşti-Obârşie (2.6 m/year) and Fundătura-Sud (1.9 m/year) gullies, both of them being valley-bottom gullies. The slope gullies usually have lower gully-head advance values, with the exception of two gullies in the Velniţa-Chirceşti system, with an average value of 1.3 m/year, fact that can be explained by their position on a cuesta front with western exposition, which has slope inclination values higher than 25^0, and by the lithological substratum. Regarding the average areal gully growth, it has an average value of 11.9 m^2/year, calculated for the 1977-2005 period. Simultaneously, a correlation between the average gully-head advance and the average areal gully growth can be noticed (Fig. 9).

A particular situation can be found in the superior Racul catchment, at Velniţa, where due to the lithological substratum (Meotian sandy deposits in the

superior part and Kersonian sandy deposits in the inferior part), combined with the morphometric and morphographic characteristics (high relief energy, slope inclinations higher than 25^0), a system of large gullies appeared in an old landslide diluvium (Fig. 10).

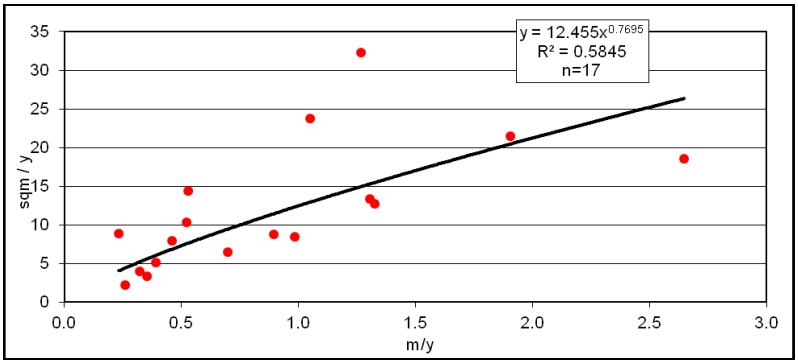

Fig. 9. Correlation between the average gully-head advance and the average areal gully growth

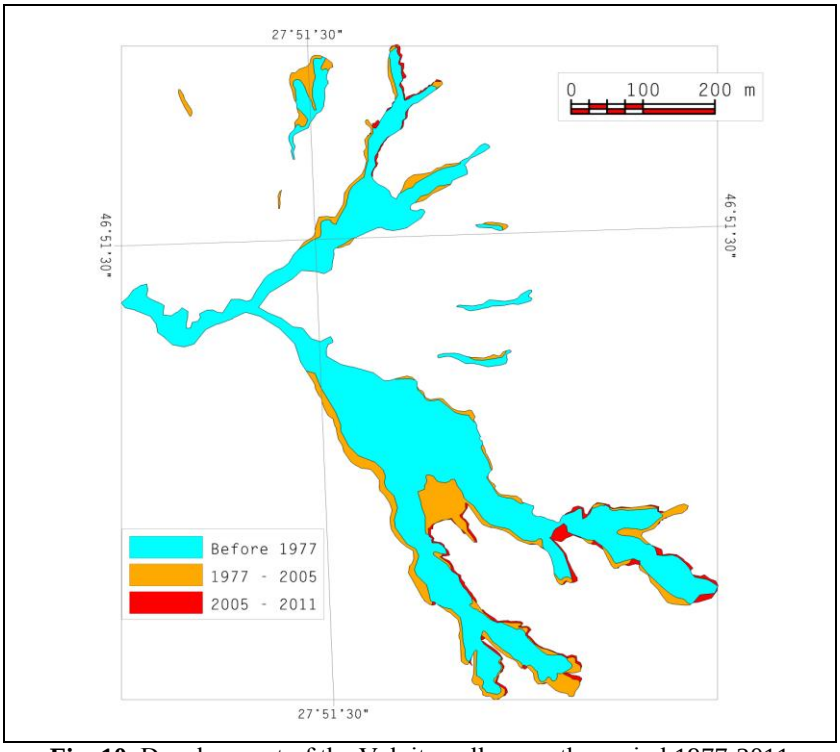

Fig. 10. Development of the Velnița gully over the period 1977-2011

The total area of the Velnița-Chirceşti gullies system is 0.11 km^2, representing about 40% of the entire gullied area in the studied region. In 1977, the gullied area was 0.09 km^2. During the 1977-2005 period, an area growth of 0.02 km^2 was registered, and during the 2005-2011 period, after the topographic elevations performed only on peak sectors, it was noticed that the area of the northern gully peak had grown by 645.2 m^2, while on the southern peak the value had grown by 3368.1 m^2.

Thus, this particular gully system is different from the other gullies in the studied region, having an area similar to those of the gullies in the Tutova Rolling Hills and Fălciu Hills, regions with a higher favorability for the appearance and the development of the gullying process. Also, associated processes can be noticed here, such as the reactivation of some landslides. Also, as a particular situation, the gullying has almost reached the watershed that separates the Racul catchment from the Crasna catchment.

IV. CONCLUSIONS

The distribution and spatial-temporal evolution of the gullying process within the Racul catchment territory, in the Central Moldavian Plateau, was accomplished through a careful analysis of the lithology and the relief morphometric and morphographic parameters. The obtained results highlighted a reduced gullying incidence, compared to other land degradation processes (landslides). The appearance of gullies is encouraged by some local factors, such as sandy lithological deposits, highly eroded soil cover, and mainly the anthropic influence, represented by the road network and the up-and-down hill farming which supports flow concentration.

Acknowledgement

This work was supported by the European Social Fund in Romania, under the responsibility of the Managing Authority for the Sectoral Operational Programme for Human Resources Development 2007-2013 [POSDRU/89/1.5/S/49944] & [POSDRU/89/1.5/S/47646].

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Received: 30.05.2012
Revised: 20.06.2012
Accepted: 04.07.2012
Published: 04.07.2012